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Lorry drivers' sedentary behaviours, physical activity and cardiovascular health

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ABSTRACT:

Objectives Elevated risk factors for a number of chronic diseases have been identified in lorry drivers. Unhealthy lifestyle behaviours such as a lack of physical activity (PA) and high levels of sedentary behaviours (sitting) likely contribute to this elevated risk. The purpose of this study is to behaviourally phenotype UK lorry drivers' sedentary and non-sedentary behaviours during workdays and non-workdays using objective measurements and to examine markers of cardiovascular health.

Setting transport company from the East Midlands, UK.

Participants 159 male participants (91% White European; [median(Range)] age: 50(24, 67)years) aged >18 years working full time as heavy good vehicle driver.

Outcomes Participants self-reported their socio-demographic information. Primary outcomes: Sedentary behaviours and PA, which were assessed over 7 days using an activPAL3 inclinometer. Cardio-metabolic markers such as Blood pressure (BP), heart rate (HR), waist circumference (WC), hip circumference (HC), and body composition were measured objectively. Blood markers such as fasting blood glucose (FBG), triglycerides (TGs), HDL-Cholesterol (HDL-C), LDL-Cholesterol (LDL-C) and Total-Cholesterol (TC) were measured from capillary blood. These cardio-metabolic markers were treated as secondary outcomes.

Results Lorry drivers' presented an unhealthy cardiovascular health profile (Median (IQR-ranges) Systolic BP: 129(108.5, 164) mmHg; Diastolic BP: 81(63, 104)mmHg; BMI: 29(20, 47) kg/m2; WC: 102(77.5, 146.5) cm; LDL-C: 3(1, 6)mmol/l; TC: 4.9(3, 7.5)mmol/l). 84% were overweight or obese, 17% had Metabolic Syndrome and 9% had type 2 diabetes. Lorry drivers accumulated 13hours/days and 8hours/day of sedentary behaviour on workdays and non-workdays ($p<0.001$), respectively. On average, drivers accrued 12min/day on workdays and 6min/day on non-workdays of moderate-to-vigorous physical activity (MVPA).

Conclusion Lorry drivers demonstrate a high-risk CVD profile and are highly sedentary and physically inactive. Interventions to reduce sitting and increase MVPA during breaks and leisure time to improve cardio-metabolic health are urgently needed. Educational programs to raise awareness about diet and exercise are recommended.

Key words: sedentary behaviours, physical activity, cardiovascular health, lorry drivers, occupational health

Strengths and limitations of this study

- This study is the first to explore sedentary behaviours, physical activity and cardiovascular health amongst lorry drivers.
- The use of the latest objective monitor to measure sedentary and upright postures during workdays and non-workdays
- The cross-sectional design that prevents us from making conclusions about causative links between sitting time and cardiovascular health.

INTRODUCTION

Lorry driving has been considered as one of the most hazardous occupations worldwide. [1-3] Long working hours, irregular working patterns and pressures to meet delivery schedules are typical in this occupation which contribute to psychological stress and sleep deprivation.[4] Furthermore, unhealthy lifestyle behaviours such as, poor diet, lack of physical activity, smoking, high volumes of alcohol consumption, and irregular sleeping patterns are highly prevalent among this occupational group.[5-7] These features contribute to an increased risk of overweight and obesity, diabetes, hypertension, heart disease, cancer, fatigue, stress, sleep disturbance, musculoskeletal disorders,[2,6,8,9] and reduced life expectancy in lorry drivers in comparison to other occupational groups. [10-12]

Sedentary behaviours defined as "any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture"[13] are prevalent in most working-aged adults, particularly in those with driving occupations.[14] It has been established that these act as an independent risk factor for increased risk of cardiovascular disease (CVD), cardiovascular mortality (CVM), all-cause mortality, diabetes[15,16] and some cancers.[16] Links between poor cardio-metabolic health and occupational driving date back to the 1950s when Morris and Crawford (1958)[17] observed higher rates of cardiovascular events and obesity in sedentary bus drivers in comparison to active conductors.

Lorry driver's lifestyle, in combination with their working environment embodies a constellation of risk factors for CVD. Whilst high volumes of sedentary time are assumed within this population, no study has specifically measured sedentary behaviour on workdays and non-workdays in lorry drivers. Furthermore, our knowledge related to lorry drivers' cardiovascular health has been derived from studies undertaken in other countries, no information currently exists on lifestyle behaviours (including sitting time and physical activity) and their relation to health in UK lorry drivers. It is essential to understand the habitual lifestyle behaviours of lorry drivers if we are to develop effective and tailored interventions to reduce the risk of the chronic diseases seen within this high-risk group. The primary aim of this study therefore was to behaviourally phenotype UK lorry drivers in terms of time spent in sedentary and non-sedentary behaviours during workdays and non-workdays. A secondary aim was to examine markers of cardiovascular health and to profile drivers' mental health.

METHODS

Study design and participants

This cross-sectional surveillance study was undertaken at a large UK-based transport company from the East Midlands. The present study is part of a programme of research undertaken in partnership with the company. This partnership was instigated by the company themselves who were seeking to better engage their drivers within the company's comprehensive health and wellbeing program. Data collection took place between May and August 2014. A volunteer sample of 159 drivers was recruited, representing 58% of the driving workforce. Drivers were recruited across all shift patterns: morning (6:00 to 14:00), afternoon (14:00 to 22:00) and night (22:00 to 6:00) on any day of the week. Participants without current CVD, haemophilia, and any blood-borne viruses were included in the analysis. Ethical approval was obtained from the local Ethical Advisory Committee and all participants provided written informed consent.

Measurements

Participant's self-reported their age, ethnicity and average weekly working hours. Drivers were asked to complete a Health Screen Questionnaire, in which they recorded any medical problems, medication, average daily intake of fruit and vegetables, average weekly alcohol intake and smoking status (current smoker, ex-smoker, amount per week). Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS).[18] Scores between 8-10 were considered borderline and those scoring 11 or over were considered as clinical 'caseness' for anxiety or depression.[18]

Resting blood pressure and heart rate were measured using the validated Omron Intellisense M7 Upper Arm monitor (Omron, UK Ltd),[19] following recommendations of the European Hypertension Society.[20] Height was measured without shoes using a portable stadiometer (Seca 206, Oxford, UK). Waist circumference was assessed using anthropometric tape at the midpoint between the upper edge of the iliac crest and the inferior border of the last palpable rib. Hip circumference was measured around the widest part of the buttocks, with the tape parallel to the floor. The waist-hip ratio was subsequently calculated. Body composition and weight were assessed using a Tanita BC-418 MA Segmental Body Composition Analyzer (Tanita UK Ltd). Percent body fat measured using the Tanita BC-418 has been shown to correlate highly with the reference measure of dual-energy X-ray absorptiometry (DXA).[21] BMI was calculated as kg/m^2.

A fasted (≥ 8 h) capillary (finger-tip) blood sample was taken for the analysis of fasting blood glucose (FBG), triglycerides (TGs), High-density lipoprotein Cholesterol (HDL), Lowdensity lipoprotein Cholesterol (LDL) and Total-Cholesterol (TC) after heating the hand for 5 minutes. A drop of blood was taken directly from the heated finger to be analysed for FBG and TGs using the Accutrend® Plus Complete System (Roche Diagnostics, Mannheim, Germany) and HDL-C and TC using the Cardiochek PA Blood Analyser (Medisave, Dorset, UK). Both devices have been validated previously.[22,23] LDL-cholesterol was estimated from quantitative measurements of total and HDL-cholesterol and plasma triglycerides using the empirical relationship of Friedewald et al (1972).[24]

Metabolic syndrome was defined as central obesity (waist circumference ≥102cm) plus any two of the following risk factors: raised blood pressure (systolic ≥130 or diastolic ≥85mmHg), raised TGs (≥1.7mmol/l), reduced HDL-C (<1.0mmol/l in males and 1.3mmol/l in females) and raised fasting plasma glucose (≥5.6mmol/l).[24] Ten year CVD risk was calculated using the QRISK calculator (http://www.qrisk.org/).[25]

Sitting, standing and physical activity

Sitting, standing and stepping time were measured objectively using an activPAL3 inclinometer, shown to be a valid measure of time spent sitting/lying, standing and walking in adults.[26,27] The activPAL3 is a small device, worn on the front of the right thigh, containing a tri-axial accelerometer which responds to signals related to gravitational forces related to thigh inclination.[28] The activPAL3 was waterproofed using a nitrile sleeve and attached to the leg using a waterproof hypoallergenic medical dressing (BSN Hypafix). This enabled participants to wear it continuously for 24 hours/day over seven days, following their health assessments. Participants were asked to complete a daily-log book where they recorded the time they went to bed and woke up on workdays and non-workdays. Information about any non-wear time was also recorded.

Data processing

Data from the activPAL were downloaded using activPAL Professional v.7.2.29 software (device firmware version 3.107) and processed manually using a customized Microsoft Excel macro. Information on sitting, standing and stepping time, including number of steps and average cadence was extracted. To be included in the analyses, participants were required to have provided at least four full days (>600 minutes of wear and >500 steps/day) of data (including at least 3 workdays and 1 non-workday). Sleeping time was identified as the last transition from standing to sitting/lying and the first transition from sitting/lying to standing during the time that best matched the participants' daily log. For each identified sleeping bout, data were explored 60 minutes before and after and included as sleeping time if sitting/lying time was ≥30 minutes and <20 steps were recorded. If any standing time with <20 steps was found during sleeping hours, this was considered as sleeping time. Non-wear time was considered as time spent in either a sitting/lying or standing position for ≥3 hours, with no transitions.

For each participant, the number of minutes spent sitting, standing and stepping during waking hours on workdays and non-workdays were extracted based on times derived from participants' logs. Stepping time was further classified into MVPA (by summing the minutes in which participants accumulated >100steps/minute)[29,30] and light activity (LPA, stepping time minus MVPA). Those accumulating ≤30 minutes/day of MVPA were considered physically inactive.[31]

Data analysis

Statistical analyses were conducted using SPSS v.22 (SPSS Inc., Chicago, IL, USA). All variables were checked for normality using the Shapiro-Wilk Test, which confirmed that the data were not normally distributed. Thus, non-parametric statistical tests were used throughout. Median and inter-quartile range (IQR) values were computed as descriptives for all variables. Wilcoxon-signed rank tests were used to compare the absolute time spent sitting, standing, and time in LPA and MVPA between workdays and non-workdays. Differences in outcomes between the three shift patterns (morning-06:00am-14:00-; afternoon -14:00 – 22:00-; and night -22:00 – 06:00) were explored using Kruskal-Wallis tests. Upon the result of a significant Kruskal-Wallis test, Bonferroni-corrected post hoc tests were conducted using a series of Mann-Whitney U tests to ascertain where the significant differences lay.

Data were further explored using linear regression models adopting an isotemporal substitution approach to quantify the association of substituting sitting behaviour with sleeping time, LPA or MVPA on cardio-metabolic markers. Prior to running the models, all behaviours (sleep, sitting, standing, LPA and MVPA) were divided by a constant of 30, which was considered as a unit of time equivalent to 30 minutes (this was chosen to comply with physical activity guidelines).[31] Consequently, every unit increase represents 30 minutes/day of any of the behavioural variables. This is a novel approach that takes into account a finite amount of time and has been recommended when assessing physical activity and sitting behaviours.[32-34]

The isotemporal substitution models were fitted to explore the impact of interchanging units of time spent sitting by any intensity of physical activity or sleeping on cardio-metabolic markers. Consequently, average wear time, sleeping time, time in LPA and MVPA were entered concurrently into a linear regression model. This was further adjusted to control for potential cofounding variables such as age, ethnicity, education levels, shift pattern, smoking, alcohol intake and fruit and vegetable consumption. Results were also adjusted by BMI. The linear coefficient for sleeping, LPA and MVPA represent the association of substituting a given unit of sitting time into each category, respectively.[32]

RESULTS

Cardiovascular profile

159 males enrolled in this study. Out of the whole sample, 87 (55%) provided activity data. Table 1 displays participants' socio-demographic information, medical information and cardiovascular markers measured for the whole sample and for the sub-sample who provided physical activity and sitting time data. Significant differences between the main cohort and the sub-cohort were only found for education levels and fasting blood glucose. Although the sample were classed as medically fit to drive, the sample displayed a high-risk cardiovascular profile (Table 1). 84% were overweight or obese, 87% were classified as physically inactive, 9% had diagnosed type II diabetes, 15% were current smokers, 17% had the Metabolic Syndrome, 35% were hypertensive, and 24% possessed >10% risk of having a cardiovascular event in the next ten years.

Table 1. Participants' demographic information. Median and IQR values are shown for the body measurements, blood pressure, blood markers and lifestyle factors for the whole sample of UK lorry drivers (N=159) and the sub-sample (n=87) who provided activity data.

	Total sample (Median (range)/number (%))	Sub-sample (Median (range)/number (%))	Differences (p value)
Age (yrs.)	50.0 (24.0, 67.0)	50(25.0, 65.0)	.504
Avg. working hours (h/week)	48.0 (27.0, 70.0)	48(27.0, 60.0)	.198
Ethnicity			.259
White European	91.0%	95.5%	
Asian/Asian British	4.5%	1.1%	
Black Caribbean	2.5%	2.3%	
Other	2.0%	1.1%	
Highest level of Education			.019
GCSEs	71.0%	94.0%	
A-levels	9.0%	2.3%	
Other	11.0%	4.5%	
Medical Information			.833
CV-related medication (BP, Thrombosis, Cholesterol)	12.4%	11.4%	
Anxiety (borderline/abnormal)	31.0%	35.2%	.314
Depression(borderline/abnormal)	15.5%	17.0%	.872
Body Composition			
% Body fat	26.0(12.2, 44.5)	24.8(12.2, 43.3)	.200
Waist circumference (cm)	102.1(77.5, 146.5)	100.9(77.5, 141.0)	.412
Waist-Hip ratio (cm)	0.95(0.8, 1.1)	0.93(0.8, 1.1)	.100
BMI (kg/m^2)	28.8(19.6, 47.2)	27.7(19.6, 43.4)	.176
Blood Pressure			
Systolic blood pressure (mmHg)	129.0(108.5, 164.0)	129.0(108.5, 155.0)	.574

Diastolic blood pressure (mmHg)	81.0(63.0, 104.0)	81.0(65.0, 104.0)	.362
Heart rate (beats/min)	62.0(42.0, 89.0)	61.0(42.0, 89.0)	.292
Blood Markers (mmol/l)			
FBG	4.6(3.3, 11.3)	5.0(3.6, 8.1)	<.001
HDL-C	1.4(0.6, 2.6)	1.4(0.9, 1.7)	.578
LDL-C	3.0(1.0, 5.7)	3.2(1.0, 5.4)	.151
TG's	1.5(0.1, 6.9)	1.5(0.7, 4.3)	.142
TC	4.9(2.6, 7.5)	5.1(2.6, 7.3)	.107
Lifestyle behaviours			
Avg. fruit and vegetables /day	5.0(0.0, 15.0)	4.3(0.0, 11.5)	.465
Alcohol units/week (n=111; sub-sample n= 88)	9.0(1.5, 60.0)	10.0(5.0, 60.0)	.129
Cigarettes/week (n=89; sub-sample n=55)	122.5(2.0, 700.0)	140.0(20.0, 700.0)	.291

activPAL-determined sitting, standing, light physical activity and MVPA.

Participants' accumulated a greater amount of sitting time on workdays compared to non-workdays (Table 2). Consequently, drivers accrued more standing time, and time in LPA on non-workdays. Nevertheless, participants acquired double the amount of time in MVPA on workdays than non-workdays.

Table 2. Sleeping, sitting, standing and stepping time and light and MVPA during workdays and non-workdays in a sample of lorry drivers from the East Midlands, UK. (n=87)

	Workdays (Median (range))	Non-Workdays (Median (range))	Differences (p value)
Sleep time (mins/day)	399.8(158.0, 774.3)	576.8(258.6, 886.9)	**< 0.001**
Waking hours (mins/day)	1040.1(813.4, 1395.4)	861.2(465.6, 1181.3)	**< 0.001**
Time spent sitting (mins/day)	749.5(493.5, 1179.9)	463.1(258.0, 787.9)	**< 0.001**

Time spent standing (mins/day)	188.7(83.3, 414.2)	226.8(85.7, 501.9)	**< 0.001**
Time in light PA (mins/day)	85.3(48.0, 169.2)	97.6(27.2, 317.2)	**<0.01**
Time in MVPA (mins/day)	12.6(1.4, 103.5)	6.0(0.0, 84.4)	**< 0.001**

Table 3 displays socio-demographic information, BMI, heart rate and activity data on workdays' for each shift pattern. Morning shift workers had greater sleeping times and lower sedentary times on workdays compared to the other shift groups. This group also exhibited significantly higher heart rates (Table 3). No other significant differences were observed between shift groups on workdays (Table 3) or non-workdays (data not shown).

Table 3. Median and range values for age, average working hours, BMI, heart rate and activity data on workdays by shift pattern in a sample of lorry drivers from the East Midlands, UK. (n=87)

	Morning shift Median(range) n = 42	Afternoon shift Median(range) n = 21	Night shift Median(range) n = 24	Differences (p value)
Age (yrs.)	51.0 (27.0, 65.0)	48.0 (28.0, 58.0)	49.5 (25.0-60.0)	.471
Avg. working hours (h/week)	10.15(5.46, 12.5)	10.5(9.2, 14.24)	10.2(9.3, 14.33)	**<0.05**
BMI (kg/m^2)	27.8(22.0, 38.7)	30.2(27.7, 43.4)	27.4 (19.6-38.6)	.507
Heart rate (beats/min)	64.5(42.0, 89.0)	61.0(47.0, 78.0)	58.5(42.0-80.0)	**<0.001**
Sleep time (mins/day)	461.3(342.3, 626.6)	316.1(157.9, 774.3)	329.9(232.2-462.3)	**<0.001**
Waking hours (mins/day)	995.0(813.4, 1116.7)	1063.2(942.2, 1395.4)	1095.7(977.7, 1207.8)	**<0.001**
Time spent sitting (mins/day)	682.5(493.5, 853.9)	779.9(556.1, 1179.9)	785.9(680.3-884.1)	**<0.001**
Time spent standing (mins/day)	177.6(91.62, 339.6)	174.6(90.0, 414.2)	194.0(133.3, 269.3)	.243
Time in light PA (mins/day)	82.1(48.0, 169.2)	81.9 (48.7, 149.4)	94.8(66.7, 140.5)	.166
Time in MVPA (mins/day)	12.6 (1.4, 103.5)	10.0(2.0, 53.7)	15.2(3.5, 72.0)	.961

* All significant P values indicate a significant difference between the morning shift group and the other two groups.

Tables 4 and 5 show the results of the Isotemporal Substitution Models which examined the impact of interchanging units of time spent sitting with LPA, MVPA or sleep on cardio-metabolic markers on workdays and non-workdays. Substituting 30 minutes of sitting for MVPA was associated with a significant reduction in waist circumference, heart rate, triglycerides and HDL-cholesterol on workdays (Table 4). These results remained significant after adjusting for BMI. No significant associations were observed in relation to substituting sitting time for light activity or sleep on workdays. No significant associations were observed when substituting 30 minutes of sitting for light activity or MVPA on non-workdays. Yet, a negative association was found between substituting 30 minutes of sitting with sleep on BMI and heart rate on non-workdays (Table 5).

Table 4. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, Pulse, Glucose, Triglycerides, HDL, LDL and Total cholesterol using isotemporal substitution on workdays in a sample of lorry drivers from East Midlands, UK.

	Sedentary to standing	P value	Sedentary to Light stepping Workdays	p value	Sedentary to moderate or vigorous stepping on Workdays	p value	Sedentary to Sleep on Workdays	p value
Waist Circumference	-0.1(-1.4, 1.2)	.870	-0.6(-3.9, 2.7)	.707	-6.5(-11.0, -1.9)	**<0.01**	0.1(-0.3, 0.5)	.500
BMI	0.07(-0.4, 0.6)	.775	-0.7(-1.9, 0.5)	.247	-1.5(-3.2, 0.2)	.089	-0.0(-0.2, 0.1)	.970
Systolic BP	0.6(-0.6, 1.9)	.338	-1.9(-5.1, 1.3)	.232	-1.1 (-5.5, 3.3)	.616	-0.3(-0.4, 0.4)	.885
Diastolic BP	0.6(-0.5, 1.7)	.313	-1.8(-4.7, 0.9)	.201	0.1(-3.8, 4.0)	.952	-0.2(-0.5, 0.2)	.280
Pulse	0.03(-1.1, 1.2)	.958	-1.9(-4.9, 1.0)	.199	-5.6(-9.6, -1.5)	**<.01**	0.1(-0.2, 0.5)	.529
Fasting Glucose	0.01(-0.1, 0.1)	.905	0.1(-0.2, 0.5)	.470	-0.4(-0.8, 0.1)	.142	0.01(-0.3, 0.05)	.784
Triglycerides	0.00(-0.1,0.1)	.940	0.06(-0.2, 0.3)	.687	-0.4(-0.8, 0.01)	**.051**	0.02(-0.01, 0.05)	.286
HDL Cholesterol	-0.02(-0.06,0.01)	.247	-0.1(-0.2,-0.01)	.035	0.3(0.1, 0.4)	**<0.01**	-0.01(-0.02, 0.01)	.314
LDL Cholesterol	-0.04(-0.2,0.1)	.559	0.2(-0.1, 0.6)	.209	-0.1(-0.6, 0.5)	.748	-0.02(-0.07, 0.02)	.281
Total Cholesterol	-0.6(-0.07,0.02)	.259	0.1(-0.2, 0.5)	.509	0.05(-0.4, 0.6)	.832	-0.2(-0.07, 0.02)	.259

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour

Table 5. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, Pulse, Glucose, Triglycerides, HDL, LDL and Total cholesterol using isotemporal substitution on non-workdays in a sample of lorry drivers from East Midlands, UK.

	Sedentary to standing	P value	Sedentary to Light stepping on Non-Workdays	p value	Sedentary to moderate or vigorous stepping on non-Workdays	p value	Sedentary to Sleep on Non-Workdays	p value
Waist Circumference	-0.4(-1.2, 2.1)	.428	0.4(-1.3, 2.1)	.612	-0.8(-4.8, 3.2)	.695	-0.4 (-1.1, 0.5)	.215
BMI	0.1(-0.5, 0.2)	.369	-0.2(-0.8, 0.4)	.509	0.2(-1.2, 1.7)	.746	-0.3(-0.5, -0.05)	**.019**
Systolic BP	-0.3(-1.1, 0.5)	.497	0.3(-1.3, 1.9)	.683	-0.01 (-3.7,3.7)	.994	-0.6(-1.2, 0.1)	.076
Diastolic BP	-0.5(-1.2, 0.2)	.167	-0.5(-1.9, 0.9)	.462	0.3(-2.9, 3.6)	.839	-0.3(-0.9, 0.2)	216
Pulse	-0.6(-1.3, 0.2)	.151	-1.0(-2.5, 0.5)	.181	-2.6(-6.1, 0.8)	.131	-0.7(-1.3, -0.01)	**.023**
Fasting Glucose	0.04(-0.05, 0.1)	.357	0.1(-0.1, 0.02)	.301	-0.3(-0.7, 0.1)	.149	0.01(-0.1, 0.1)	.828
Triglycerides	-0.03(-0.1,0.04)	.417	0.07(-0.07, 0.2)	.303	-0.2(-0.5, 1.0)	.380	-0.02(-0.08, 0.04)	.500
HDL Cholesterol	0.02(-0.01,0.05)	.281	-0.05(-0.1, 0.01)	.119	0.07(-1.0, 0.2)	.359	0.0 (-0.02, 0.03)	.732
LDL Cholesterol	-0.08(-0.2,0.01)	.084	0.0(-0.2, 0.2)	.919	-0.01(-0.5, 0.4)	.946	-0.04(-0.2, 0.04)	.084
Total Cholesterol	-0.08(-0.2,0.02)	.100	-0.03(-0.2, 0.1)	.887	0.03(-0.4, 0.5)	.887	-0.03(-0.1, 0.04)	.368

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour

DISCUSSION

This cross-sectional study highlights the high-risk cardiovascular health profile and the high levels of objectively measured sitting time and low levels of MVPA amongst a sample of UK lorry drivers. This study is the first of its kind to objectively measure lorry driver's sedentary behaviours using inclinometry, which were particularly high on workdays (13 hours/day) compared to non-workdays (8 hours/day). Using an isotemporal modelling approach, this study indicates that reallocating 30 minutes of sedentary time to moderate-to-vigorous stepping, during workdays, and sleeping time, on non-workdays, was linked to favourable levels of waist circumference, heart rate, triglycerides, HDL-cholesterol and BMI.

Sitting, standing and movement patterns in lorry drivers compared to other occupational drivers and the general population.

Occupational drivers can be defined as "compulsory sedentary workers", yet limited research has directly examined sedentary time in this occupational group and of the research available,[14,17,35,36] only one study used similar methods.[14] Prolonged time sitting has been strongly related to higher rates of overweight and obesity, adverse cardiovascular biomarkers, premature mortality, the Metabolic Syndrome and depression.[15,37,38] The present findings show that lorry drivers accumulate higher volumes of daily sitting on workdays in comparison to bus drivers (13hours/day versus 12hours/day), who have been found to be highly sedentary compared to the general population.[14] Lorry drivers accumulated more sleeping time during non-workdays than seen in bus drivers,[14] which could be understood as a compensational behaviour for the shortage of sleep during workdays. Indeed, several studies have shown that lorry drivers are a sleep deprived group, averaging 3.8 to 5.2 hours of sleep daily.[39,40] This research also highlighted the high prevalence of physical inactivity; which has been defined as one of the major contributors to ill-health.[41] Indeed, only 13% of the present sample were considered physically active, which is similar to lorry drivers from other countries.[1,5,12]

Using Isotemporal Substitution Modelling, our findings indicate that interchanging 30 minutes/day of sedentary time with moderate-to-vigorous stepping had positive associations with some cardio-metabolic risk markers. The protective effects of MVPA on health have previously been established;[16] these results suggest that only substituting time spent sedentary for MVPA, and not standing time or light activity, will have beneficial effects on health parameters within this population. Further research should confirm these findings.

Cardiovascular health profile in lorry drivers compared to other occupational drivers and the general population.

Cardiovascular diseases are the largest cause of mortality in the UK accounting for 27% of all deaths.[42] Occupational demands and unhealthy lifestyle behaviours give lorry drives a unique constellation of risk factors for CVD. Drivers from this study showed a higher prevalence of overweight and obesity compared to males aged 45-54 years in the UK (84% versus 79.4%).[43] Weight-related co-morbidities such as pre-diabetes, diagnosed type II diabetes and hypertension were also higher in this sample compared to the general population (9% versus 6% and 35% versus 31.5%, respectively).[43,44] The increased rates of overweight and obesity within this occupational group is a concern, given evidence suggests that obese lorry drivers are 55% more likely to have an accident than normal weight drivers[45]. The present findings are in-line with research conducted on US lorry drivers,[46] which demonstrate a high prevalence of unhealthy lifestyle behaviours, and increased risk factors for CVD. Indeed, US and UK data show that lorry drivers have a reduced life expectancy compared to other professions.[47,48] Despite the above evidence, lorry drivers are considered an underserved group in terms of health promotion efforts.[49]

Does lorry driving impact mental health?

Lorry drivers endure a long working-hours culture which requires sustained attention for prolonged periods. Several internal and external factors such as strict schedules, timetables, road traffic, prolonged time sitting and shortage of sleep (as shown in this paper) induce drivers to cope with stressful situations on a daily basis. The rotating shifts and the duration of these can negatively impact family-work life-balance, resulting in a socially isolating job. These job-related constraints enhance continuous psycho-physiological arousal, resulting in serious levels of fatigue;[50-52] hence the high incidence of mental-health conditions amongst this population.[53] In fact, 46% of the present sample were clustered as borderline or abnormal cases of anxiety and depression, which is higher than that seen in American lorry drivers (41.5%).[53] However, most cases of mental ill-health within this occupational group reportedly go untreated.[47,53] Sustained psycho-physiological arousal at work has been linked to cancer, ischaemic heart disease, accidents and poor mental health.[12,54-56]

Limitations and strengths

The cross-sectional design prevents us from making conclusions about causative links between sitting time and cardiovascular health. Secondly, the sample was recruited from one transport depot in the East Midlands, which makes it difficult to generalise findings across the UK or abroad. Finally, data collection took place during summer time, which is the busiest time at this transport company. Exploring drivers' sedentary and physical activity behaviours' across all seasons is therefore recommended for future research. Despite these limitations, this is the first study to provide objective information on lorry drivers' sitting time during workdays and non-workdays. We utilised a novel sedentary and physical activity monitor which directly distinguishes between sedentary and upright postures thus overcoming limitations of self-report measures or other types of accelerometer that do not directly measure posture. In addition we explored lorry drivers' health from a holistic perspective for a better understanding of drivers' sitting time and cardiovascular health.

CONCLUSION

Results from this study provide new information on lorry drivers' lifestyle behaviours and health. The high prevalence of various risk factors put drivers at high risk of numerous health conditions and premature mortality. Occupational interventions are urgently needed to reduce excessive adverse health behaviours and fatalities within this high risk workforce. Interventions should focus on reducing sitting and increasing MVPA during work breaks and leisure time. Within the present sample, and across the transport sector more broadly, our experience has shown that lorry drivers are an occupational group who have proven difficult to engage within health and wellbeing initiatives. Additional qualitative research is therefore a priority to identify effective strategies that are able to engage lorry drivers which will underpin the successfulness of future health promotion interventions.

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Disclaimer

The authors wish to state that all drivers participating in this study were medically fit to drive and comply with the DVLA requirements.

Contributors VVM and SC conceived the study. MN and JK stablished the partnership between the university and the local company. VVM, OO and JK designed and implemented the data collection. SC, TY, SB and DS overviewed the data collection. All authors contributed to writing and interpretation of the results.

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Lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health

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Lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health

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ABSTRACT:

Objectives: Elevated risk factors for a number of chronic diseases have been identified in lorry drivers. Unhealthy lifestyle behaviours such as a lack of physical activity (PA) and high levels of sedentary behaviour (sitting) likely contribute to this elevated risk. This study behaviourally phenotyped UK lorry drivers' sedentary and non-sedentary behaviours during workdays and non-workdays and examined markers of drivers cardio-metabolic health.

Setting: a transport company from the East Midlands, UK.

Participants: a sample of 159 male heavy goods vehicle drivers (91% White European; [median(Range)] age: 50(24, 67)years) completed the health assessments. 87 (age: 50.0(25.0, 65.0); BMI: 27.7(19.6, 43.4)kg/m^2) provided objective information on sedentary and non-sedentary time.

Outcomes: Participants self-reported their socio-demographic information. Primary outcomes: Sedentary behaviour and PA, assessed over 7 days using an activPAL3 inclinometer. Cardio-metabolic markers included: blood pressure (BP), heart rate (HR), waist circumference (WC), hip circumference (HC), body composition, and fasted capillary blood glucose (FBG), triglycerides (TGs), HDL-Cholesterol (HDL-C), LDL-Cholesterol (LDL-C) and Total-Cholesterol (TC) levels. These cardio-metabolic markers were treated as secondary outcomes.

Results: Lorry drivers' presented an unhealthy cardio-metabolic health profile (median (IQR-ranges) Systolic BP: 129(108.5, 164) mmHg; Diastolic BP: 81(63, 104)mmHg; BMI: 29(20, 47)kg/m^2; WC: 102(77.5, 146.5)cm; LDL-C: 3(1, 6)mmol/l; TC: 4.9(3, 7.5)mmol/l). 84% were overweight or obese, 43% had type 2 diabetes or pre-diabetes and 34% had the Metabolic Syndrome. The sub-sample of lorry drivers with objective postural data (n=87) accumulated 13hours/day and 8hours/day of sedentary behaviour on workdays and non-workdays (p<0.001), respectively. On average, drivers accrued 12min/day on workdays and 6min/day on non-workdays of moderate-to-vigorous PA (MVPA).

Conclusion: Lorry drivers demonstrate a high-risk cardio-metabolic profile and are highly sedentary and physically inactive. Interventions to reduce sitting and increase MVPA during breaks and leisure-time to improve cardio-metabolic health are urgently needed. Educational programs to raise awareness about diet and exercise are recommended.

Key words: sedentary behaviours, physical activity, cardio-metabolic health, lorry drivers, occupational health

Strengths and limitations of this study

- This study is the first to explore sedentary behaviour, physical activity and cardiovascular health amongst lorry drivers.
- The use of the latest objective monitor to measure sedentary and upright postures during workdays and non-workdays
- The cross-sectional design that prevents us from making conclusions about causative links between sitting time and cardio-metabolic health.

INTRODUCTION

Lorry driving has been considered as one of the most hazardous occupations worldwide. [1-3] Long working hours, irregular working patterns and pressures to meet delivery schedules are typical in this occupation which contribute to psychological stress and sleep deprivation.[4] Furthermore, unhealthy lifestyle behaviours such as, poor diet, lack of physical activity, smoking, high volumes of alcohol consumption, and irregular sleeping patterns are highly prevalent among this occupational group.[5-7] These features contribute to an increased risk of overweight and obesity, diabetes, hypertension, heart disease, cancer, fatigue, stress, sleep disturbance, musculoskeletal disorders,[2,6,8,9] and reduced life expectancy in lorry drivers in comparison to other occupational groups. [10-12]

Sedentary behaviours defined as “any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture”[13] are prevalent in most working-aged adults, particularly in those with driving occupations.[14] It has been established that these act as an independent risk factor for increased risk of cardiovascular disease (CVD), cardiovascular mortality (CVM), all-cause mortality, diabetes[15,16] and some cancers.[16] Links between poor cardio-metabolic health and occupational driving date back to the 1950s when Morris and Crawford (1958)[17] observed higher rates of cardiovascular events and obesity in sedentary bus drivers in comparison to active conductors.

Lorry driver’s lifestyle, in combination with their working environment embodies a constellation of risk factors for CVD. Whilst high volumes of sedentary time are assumed within this population, no study has specifically measured sedentary behaviour on workdays and non-workdays in lorry drivers. Furthermore, our knowledge related to lorry drivers' cardio-metabolic health has been derived from studies undertaken in other countries, no information currently exists on lifestyle behaviours (including sitting time and physical activity) and their relation to health in UK lorry drivers. It is essential to understand the habitual lifestyle behaviours of lorry drivers if we are to develop effective and tailored interventions to reduce the risk of the chronic diseases seen within this high-risk group. The primary aim of this study therefore was to behaviourally phenotype UK lorry drivers in terms of time spent in sedentary and non-sedentary behaviours during workdays and non-workdays and working hours and non-working hours. A secondary aim was to examine markers of cardio-metabolic health and to profile drivers' mental health.

METHODS

Study design and participants

This cross-sectional surveillance study was undertaken at a large UK-based transport company from the East Midlands. The present study is part of a programme of research undertaken in partnership with the company. This partnership was instigated by the company themselves who were seeking to better engage their drivers within the company's comprehensive health and wellbeing program. Data collection took place between May and August 2014. A volunteer sample of 159 long-distance heavy goods vehicle drivers was recruited, representing 58% of the driving workforce. Drivers were recruited across all shift patterns: morning (6:00 to 14:00), afternoon (14:00 to

22:00) and night (22:00 to 6:00) on any day of the week. Participants without current CVD, haemophilia, and any blood-borne viruses were included in the analysis. Ethical approval was obtained from the local Ethical Advisory Committee and all participants provided written informed consent.

Measurements

Participant's self-reported their age, ethnicity and average weekly working hours. Drivers were asked to complete a Health Screen Questionnaire, in which they recorded any medical problems, medication, average daily intake of fruit and vegetables, average weekly alcohol intake and smoking status (current smoker, ex-smoker, amount per week). Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS).[18] Scores between 8-10 were considered borderline and those scoring 11 or over were considered as clinical 'caseness' for anxiety or depression.[18]

Resting blood pressure and heart rate were measured using the validated Omron Intellisense M7 Upper Arm monitor (Omron, UK Ltd),[19] following recommendations of the European Hypertension Society.[20] Height was measured without shoes using a portable stadiometer (Seca 206, Oxford, UK). Waist circumference was assessed using anthropometric tape at the midpoint between the upper edge of the iliac crest and the inferior border of the last palpable rib. Hip circumference was measured around the widest part of the buttocks, with the tape parallel to the floor. The waist-hip ratio was subsequently calculated. Body composition and weight were assessed using a Tanita BC-418 MA Segmental Body Composition Analyzer (Tanita UK Ltd). Percent body fat measured using the Tanita BC-418 has been shown to correlate highly with the reference measure of dual-energy X-ray absorptiometry (DXA).[21] BMI was calculated as kg/m^2.

A fasted (≥ 8 h) capillary (finger-tip) blood sample was taken for the analysis of fasting blood glucose (FBG), triglycerides (TGs), High-density lipoprotein Cholesterol (HDL), Low-density lipoprotein Cholesterol (LDL) and Total-Cholesterol (TC) after heating the hand for 5 minutes. A drop of blood was taken directly from the heated finger to be analysed for FBG and TGs using the Accutrend® Plus Complete System (Roche Diagnostics, Mannheim, Germany) and HDL-C and TC using the Cardiochek PA Blood Analyser (Medisave, Dorset, UK). Both devices have been validated previously.[22,23] LDL-cholesterol was estimated from quantitative measurements of total and HDL-cholesterol and plasma triglycerides using the empirical relationship of Friedewald et al (1972).[24]

Metabolic syndrome was defined according to the International Diabetes Federation as central obesity (waist circumference ≥102cm) plus any two of the following risk factors: raised blood pressure (systolic ≥130 or diastolic ≥85mmHg), raised TGs (≥1.7mmol/l), reduced HDL-C (<1.0mmol/l in males and 1.3mmol/l in females) and raised fasting plasma glucose (≥5.6mmol/l).[25] Ten year CVD risk was calculated using the QRISK calculator (http://www.qrisk.org/).[26]

Sitting, standing and physical activity

Sitting, standing and stepping time were measured objectively using an activPAL3 accelerometer, shown to be a valid measure of time spent sitting/lying, standing and walking in adults.[27,28] The activPAL3 is a small device, worn on the front of the right thigh, containing a tri-axial accelerometer which responds to signals related to gravitational forces related to thigh inclination.[29] The activPAL3 was waterproofed using a nitrile sleeve and attached to the leg using a waterproof hypoallergenic medical dressing (BSN Hypafix). This enabled participants to wear it continuously for 24 hours/day over seven days, following their health assessments. Participants were asked to complete a daily-log book where they recorded the time they went to bed and woke up on workdays and non-workdays. Information about any non-wear time was also recorded.

Data processing

Data from the activPAL were downloaded using activPAL Professional v.7.2.29 software (device firmware version 3.107) and processed manually using a customized Microsoft Excel macro. Information on sitting, standing and stepping time, including transitions from sitting to standing, number of steps and average cadence was extracted. To be included in the analyses, participants were required to have provided at least four full days (>600 minutes of wear and >500 steps/day) of data (including at least 3 workdays and 1 non-workday). Sleeping time was identified as the last transition from standing to sitting/lying and the first transition from sitting/lying to standing during the time that best matched the participants' daily log. For each identified sleeping bout, data were explored 60 minutes before and after and included as sleeping time if sitting/lying time was ≥30 minutes and <20 steps were recorded. If any standing time with <20 steps was found during sleeping hours, this was considered as sleeping time. To control for errors associated with self-reported diary data, non-wear time was considered as time spent in either a sitting/lying or standing position for ≥3 hours, with no transitions. This cut-point was established based on checks conducted in the dataset and techniques described elsewhere.[30]

For each participant, the number of minutes spent sitting, standing and stepping and transitions from sitting to standing during waking hours on workdays and non-workdays were extracted based on times derived from participants' logs. Stepping time was further classified into MVPA (by summing the minutes in which participants accumulated >100steps/minute) [31,32] and light activity (LPA, stepping time minus MVPA). Those accumulating ≤30 minutes/day of MVPA were considered physically inactive.[33]

Data analysis

Statistical analyses were conducted using SPSS v.22 (SPSS Inc., Chicago, IL, USA). All variables were checked for normality using the Shapiro-Wilk Test, which confirmed that all data were not normally distributed. Thus, non-parametric statistical tests were used throughout. Median and inter-quartile range (IQR) values were computed as descriptives for all variables. Wilcoxon-signed rank tests were used to compare the absolute time spent sitting, standing, and time in LPA and MVPA, total steps and transitions from sitting to standing between workdays and non-workdays and working hours and non-working hours. Differences in outcomes between the three shift patterns (morning-06:00am-14:00-; afternoon -14:00 – 22:00-; and night -22:00 – 06:00) were explored using Kruskal-Wallis tests. Upon the result of a significant Kruskal-Wallis test, Bonferroni-corrected post hoc tests were conducted using a series of Mann-Whitney U tests to ascertain where the significant differences lay.

Data were further explored using linear regression models adopting an isotemporal substitution approach to quantify the association of substituting sitting behaviour with sleeping time, LPA or MVPA on cardio-metabolic markers. Prior to running the models, all behaviours (sleep, sitting, standing, LPA and MVPA) were divided by a constant of 30, which was considered as a unit of time equivalent to 30 minutes (this was chosen to comply with physical activity guidelines).[33] Consequently, every unit increase represents 30 minutes/day of any of the behavioural variables. This is a novel approach that takes into account a finite amount of time and has been recommended when assessing physical activity and sitting behaviours.[34-36]

The isotemporal substitution models were fitted to explore the impact of interchanging units of time spent sitting by any intensity of physical activity or sleeping on cardio-metabolic markers. Consequently, average wear time, sleeping time, time in LPA and MVPA were entered concurrently into a linear regression model. This was further adjusted to control for potential cofounding variables such as age, ethnicity, education levels, shift pattern, smoking, alcohol intake and fruit and vegetable consumption. Results were also adjusted by BMI. The linear coefficient for sleeping, LPA and MVPA represent the association of substituting a given unit of sitting time into each category, respectively.[34]

RESULTS

Participants

A sample of 159 male lorry drivers participated in the health assessments (median (IQR-ranges): age: 50.0 (24.0, 67.0) years; BMI: 29(20, 47) kg/m^2). Out of the main cohort (N=159) a sub-sample of 87 lorry drivers (55%) provided additional valid activPAL data (age: 50.0(25.0, 65.0) years; BMI: 27.7(19.6, 43.4) kg/m^2). Those not complying with the activPAL protocol for valid data (n=72; age: 52.0(24.0, 67.0) years) had significantly higher waist-hip ratio (0.96 (0.81, 1.15)), percentage body fat (27.1(15.4, 44.5) %), BMI (29.9(19.9, 47.2) kg/m^2), FBG (5.7 (4.0, 9.1) mmol/l) and lower alcohol consumption (units of alcohol: 7.9 (1.0, 23.0)) in comparison to those providing valid activPAL data.

Cardio-metabolic health profile

Table 1 displays participants' socio-demographic information, medical information and cardio-metabolic markers measured for the whole sample (N=159) and for the sub-sample (n=87). Significant differences between the main cohort and the sub-cohort were only found for education levels. Although lorry drivers participating in this study were classed as medically fit to drive, the sample displayed a high-risk cardio-metabolic profile (Table 1). Out of 159 drivers, 84% were overweight or obese, 10% had diagnosed type II diabetes, 29% had pre-diabetes, 4% had undiagnosed diabetes, 34% had the Metabolic Syndrome, 27% were pre-hypertensive, 29% were hypertensive, 24% possessed >10% risk of having a cardiovascular event in the next ten years and 15% were current smokers. In addition, of those who provided activPAL data (n=87), 87% were classified as physically inactive.

Table 1. Participants' demographic information. Median and IQR values are shown for the body measurements, blood pressure, blood markers and lifestyle factors for the whole sample of UK lorry drivers (N=159) and the sub-sample (n=87) who provided activity data.

	Total sample (Median (range)/number (%))	Sub-sample (Median (range)/number (%))	Differences (p value)
Age (yrs.)	50.0 (24.0, 67.0)	50(25.0, 65.0)	.504
Avg. working hours (h/week)	48.0 (27.0, 70.0)	48(27.0, 60.0)	.198
Ethnicity			.259
White European	91.0%	95.5%	
Asian/Asian British	4.5%	1.1%	
Black Caribbean	2.5%	2.3%	
Other	2.0%	1.1%	
Highest level of Education			.019
GCSEs	71.0%	94.0%	
A-levels	9.0%	2.3%	
Other	11.0%	4.5%	
Medical Information			.833
CV-related medication (BP, Thrombosis, Cholesterol)	12.4%	11.4%	
Anxiety (borderline/abnormal)	31.0%	35.2%	.314
Depression(borderline/abnormal)	15.5%	17.0%	.872
Body Composition			

% Body fat	26.0(12.2, 44.5)	24.8(12.2, 43.3)	.200
Waist circumference (cm)	102.1(77.5, 146.5)	100.9(77.5, 141.0)	.412
Waist-Hip ratio (cm)	0.95(0.8, 1.1)	0.93(0.8, 1.1)	.100
BMI (kg/m^2)	28.8(19.6, 47.2)	27.7(19.6, 43.4)	.176
Blood Pressure			
Systolic blood pressure (mmHg)	129.0(108.5, 164.0)	129.0(108.5, 155.0)	.574
Diastolic blood pressure (mmHg)	81.0(63.0, 104.0)	81.0(65.0, 104.0)	.362
Heart rate (beats/min)	62.0(42.0, 89.0)	61.0(42.0, 89.0)	.292
Blood Markers (mmol/l)			
FBG	5.4(3.7, 12.7)	5.1(3.7, 12.7)	.491
HDL-C	1.4(0.6, 2.6)	1.4(0.9, 1.7)	.578
LDL-C	3.0(1.0, 5.7)	3.2(1.0, 5.4)	.151
TG's	1.5(0.1, 6.9)	1.5(0.7, 4.3)	.142
TC	4.9(2.6, 7.5)	5.1(2.6, 7.3)	.107
Lifestyle behaviours			
Avg. fruit and vegetables /day	5.0(0.0, 15.0)	4.3(0.0, 11.5)	.465
Alcohol units/week (n=111; sub-sample n= 88)	9.0(1.5, 60.0)	10.0(5.0, 60.0)	.129
Cigarettes/week (n=89; sub-sample n=55)	122.5(2.0, 700.0)	140.0(20.0, 700.0)	.291

activPAL-determined sitting, standing, light physical activity and MVPA.

Participants providing valid activPAL data wore the device continuously (24 hours per day) for at least four days, overall this sample had a median wear duration of 6.5 (0.7) days. Median activPAL-determined waking hours were greater for workdays than for non-workdays (p<0.001). Participants' accumulated significantly greater amounts of sitting time on workdays compared to non-workdays and during working hours compared to non-working hours (Table 2). Consequently, drivers accrued more standing time and time in LPA on non-workdays and during non-working hours.

Nevertheless, participants acquired double the amount of time in MVPA ($p<.001$) on workdays than non-workdays and broke up their sitting time more often on workdays compared to non-workdays and during working hours compared to non-working hours ($p<0.01$) (table 2).

Table 2. Sleeping, sitting, standing, light and MVPA and transitions from sitting to standing during workdays and non-workdays and working hours to non-working hours in a sample of lorry drivers from the East Midlands, UK. (n=87)

	All days (median ± IQR)			Work days only (median ± IQR)		
	Workdays	Non-workdays	Differences (p value)	Working hours	Non-working hours	Differences (p value)
Sleep time (mins/day)	399.8(158.0, 774.3)	576.8(258.6, 886.9)	**< 0.001**			
Waking time (mins/day)	1040.1(813.4, 1395.4)	861.2(465.6, 1181.3)	**< 0.001**	628.8(344.7, 838.1)	421.4(136.1, 770.1)	**< 0.01**
Time spent sitting (mins/day)	749.5(493.5, 1179.9)	463.1(258.0, 787.9)	**< 0.001**	491.5(148.6, 678.2)	239.9(101.8, 600.4)	**<0.001**
Time spent standing (mins/day)	188.7(83.3, 414.2)	226.8(85.7, 501.9)	**< 0.001**	70.4(24.6, 284.1)	105.5(27.6, 302.5)	**< 0.001**
Time in light PA (mins/day)	85.3(48.0, 169.2)	97.6(27.2, 317.2)	**<0.01**	39.7(8.2, 95.8)	47.0(9.6, 118.6)	**< 0.05**
Time in MVPA (mins/day)	12.6(1.4, 103.5)	6.0(0.0, 84.4)	**< 0.001**	4.4(0.3, 26.2)	5.8(0.0, 96.0)	**< 0.01**
Total steps per day	8074.9(3411.3, 21420.0)	7854.8(1008.0, 23308.0)	.656	3659.9(2148.4, 9177.9)	4324.5(634.0, 17469.0)	.052
Number of transitions from sitting to standing	47.9(18.0)	40.0(26.0)	**< 0.01**	26.6(9.0, 58.0)	20.7(4.0, 51.0)	**<0.01**

Table 3 displays socio-demographic information, BMI, and activity data on workdays' for each shift pattern. Morning shift workers had greater sleeping times and lower sedentary times on workdays compared to the other shift groups. Afternoon shift workers accumulated less transitions from sitting to standing compared to morning and night workers during non-workdays (afternoon shift: 31.5(21.0, 63.0); morning shift: 47.5(16.0, 100.0); night shift (46.0(21.0, 91.0); p<.05) and during non-working hours compared to night workers (afternoon shift: 16.9(8.0, 51.0); night shift (25.2(14.0, 37.0); p<.01) No other significant differences were observed between shift groups on workdays (Table 3) or non-workdays (data not shown).

Table 3. Median and range values for age, average working hours, BMI, and activity data on workdays by shift pattern in a sample of lorry drivers from the East Midlands, UK. (n=87)

	Morning shift Median(range) n = 42	Afternoon shift Median(range) n = 21	Night shift Median(range) n = 24	Differences (p value)
Age (yrs.)	51.0 (27.0, 65.0)	48.0 (28.0, 58.0)	49.5 (25.0-60.0)	.471
Avg. working hours (h/day)	10.15(5.46, 12.5)	10.5(9.2, 14.24)	10.2(9.3, 14.33)	**<0.05**
BMI (kg/m^2)	27.8(22.0, 38.7)	30.2(27.7, 43.4)	27.4 (19.6-38.6)	.507
Sleep time (mins/day)	461.3(342.3, 626.6)	316.1(157.9, 774.3)	329.9(232.2-462.3)	**<0.001**
Waking hours (mins/day)	995.0(813.4, 1116.7)	1063.2(942.2, 1395.4)	1095.7(977.7, 1207.8)	**<0.001**
Time spent sitting (mins/day)	682.5(493.5, 853.9)	779.9(556.1, 1179.9)	785.9(680.3-884.1)	**<0.001**
Time spent standing (mins/day)	177.6(91.62, 339.6)	174.6(90.0, 414.2)	194.0(133.3, 269.3)	.243
Time in light PA (mins/day)	82.1(48.0, 169.2)	81.9 (48.7, 149.4)	94.8(66.7, 140.5)	.166
Time in MVPA (mins/day)	12.6 (1.4, 103.5)	10.0(2.0, 53.7)	15.2(3.5, 72.0)	.961
Total steps per day	7551.6(4136.7, 12516.4)	8083.2(4824.7, 11895.0)	9010.0(5999.2, 15618.5)	.141
Transitions from sitting to standing	46.4(25.0, 88.0)	45.9(35.0, 107.0)	53.2(35.0, 69.0)	.110

* All significant P values indicate a significant difference between the morning shift group and the other two groups.

Tables 4 and 5 show the results of the Isotemporal Substitution Models which examined the impact of interchanging units of time spent sitting with LPA, MVPA or sleep on cardio-metabolic markers on workdays and non-workdays. Substituting 30 minutes of sitting for MVPA was associated with a significant reduction in waist circumference, triglycerides and HDL-cholesterol on workdays (Table 4). These results remained significant after adjusting for BMI. No significant associations were observed in relation to substituting sitting time for light activity or sleep on workdays. No significant associations were observed when substituting 30 minutes of sitting for light activity or MVPA on non-workdays. Yet, a negative association was found between substituting 30 minutes of sitting with sleep on BMI on non-workdays (Table 5).

Table 4. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, Pulse, Glucose, Triglycerides, HDL, LDL and Total cholesterol using isotemporal substitution on workdays in a sample of lorry drivers from East Midlands, UK.

	Sedentary to standing	P value	Sedentary to Light stepping Workdays	p value	Sedentary to moderate or vigorous stepping on Workdays	p value	Sedentary to Sleep on Workdays	p value
Waist Circumference	-0.1(-1.4, 1.2)	.870	-0.6(-3.9, 2.7)	.707	-6.5(-11.0, -1.9)	**<0.01**	0.1(-0.3, 0.5)	.500
BMI	0.07(-0.4, 0.6)	.775	-0.7(-1.9, 0.5)	.247	-1.5(-3.2, 0.2)	.089	-0.0(-0.2, 0.1)	.970
Systolic BP	0.6(-0.6, 1.9)	.338	-1.9(-5.1, 1.3)	.232	-1.1 (-5.5, 3.3)	.616	-0.3(-0.4, 0.4)	.885
Diastolic BP	0.6(-0.5, 1.7)	.313	-1.8(-4.7, 0.9)	.201	0.1(-3.8, 4.0)	.952	-0.2(-0.5, 0.2)	.280
Fasting Glucose	-0.01(-0.1, 0.1)	.859	-0.04(-0.3, 0.2)	.774	-0.3(-0.6, 0.1)	.144	-0.04(-0.1, 0.02)	.137
Triglycerides	0.00(-0.1,0.1)	.940	0.06(-0.2, 0.3)	.687	-0.4(-0.8, 0.01)	**.051**	0.02(-0.01, 0.05)	.286
HDL Cholesterol	-0.02(-0.06,0.01)	.247	-0.1(-0.2,-0.01)	.035	0.3(0.1, 0.4)	**<0.01**	-0.01(-0.02, 0.01)	.314
LDL Cholesterol	-0.04(-0.2,0.1)	.559	0.2(-0.1, 0.6)	.209	-0.1(-0.6, 0.5)	.748	-0.02(-0.07, 0.02)	.281
Total Cholesterol	-0.6(-0.07,0.02)	.259	0.1(-0.2, 0.5)	.509	0.05(-0.4, 0.6)	.832	-0.2(-0.07, 0.02)	.259

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour

Table 5. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, Pulse, Glucose, Triglycerides, HDL, LDL and Total cholesterol using isotemporal substitution on non-workdays in a sample of lorry drivers from East Midlands, UK.

	Sedentary to standing	P value	Sedentary to Light stepping on Non-Workdays	p value	Sedentary to moderate or vigorous stepping on non-Workdays	p value	Sedentary to Sleep on Non-Workdays	p value
Waist Circumference	-0.4(-1.2, 2.1)	.428	0.4(-1.3, 2.1)	.612	-0.8(-4.8, 3.2)	.695	-0.4 (-1.1, 0.5)	.215
BMI	0.1(-0.5, 0.2)	.369	-0.2(-0.8, 0.4)	.509	0.2(-1.2, 1.7)	.746	-0.3(-0.5, -0.05)	**.019**
Systolic BP	-0.3(-1.1, 0.5)	.497	0.3(-1.3, 1.9)	.683	-0.01 (-3.7,3.7)	.994	-0.6(-1.2, 0.1)	.076
Diastolic BP	-0.5(-1.2, 0.2)	.167	-0.5(-1.9, 0.9)	.462	0.3(-2.9, 3.6)	.839	-0.3(-0.9, 0.2)	216
Fasting Glucose	0.01(-0.07, 0.1)	.753	0.03(-0.1, 0.2)	.648	-0.3(-0.7, 0.05)	.090	-0.00(-0.06, 0.06)	.931
Triglycerides	-0.03(-0.1,0.04)	.417	0.07(-0.07, 0.2)	.303	-0.2(-0.5, 1.0)	.380	-0.02(-0.08, 0.04)	.500
HDL Cholesterol	0.02(-0.01,0.05)	.281	-0.05(-0.1, 0.01)	.119	0.07(-1.0, 0.2)	.359	0.0 (-0.02, 0.03)	.732
LDL Cholesterol	-0.08(-0.2,0.01)	.084	0.0(-0.2, 0.2)	.919	-0.01(-0.5, 0.4)	.946	-0.04(-0.2, 0.04)	.084
Total Cholesterol	-0.08(-0.2,0.02)	.100	-0.03(-0.2, 0.1)	.887	0.03(-0.4, 0.5)	.887	-0.03(-0.1, 0.04)	.368

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour

DISCUSSION

This cross-sectional study highlights the high-risk cardio-metabolic health profile and the high levels of objectively measured sitting time and low levels of MVPA amongst a sample of UK lorry drivers. This study is the first of its kind to objectively measure lorry driver's sedentary behaviours using inclinometry, which were particularly high on workdays (13 hours/day) compared to non-workdays (8 hours/day). Using an isotemporal modelling approach, this study indicates that reallocating 30 minutes of sedentary time to moderate-to-vigorous stepping, during workdays, and sleeping time, on non-workdays, was linked to favourable levels of triglycerides, HDL-cholesterol, BMI and waist circumference.

Sitting, standing and movement patterns in lorry drivers compared to other occupational drivers and the general population.

Occupational drivers can be defined as "compulsory sedentary workers", yet limited research has directly examined sedentary time in this occupational group and of the research available,[14,17,37,38] only one study used similar methods.[14] Prolonged time sitting has been strongly related to higher rates of overweight and obesity, adverse cardiovascular biomarkers, premature mortality, the Metabolic Syndrome and depression.[15,37,39,40] The present findings suggest that lorry drivers accumulate higher volumes of daily sitting on workdays in comparison to bus drivers (13hours/day versus 12hours/day), who have been found to be highly sedentary compared to the general population.[14] However, this sample of drivers spent less time sedentary on non-workdays compared to workdays (8 hours/day versus 13 hours/day), which could in part be explained by the observation that drivers accumulated more sleeping time during non-workdays (576.8 (258.6, 886.9) minutes) than workdays (399.8 (158.0, 774.3)minutes). This could be understood as a compensational behaviour for the shortage of sleep during workdays induced by the shift patterns and long hours at work. Indeed, several studies have shown that lorry drivers are a sleep deprived group due to their shift patterns and work duration, averaging 3.8 to 5.2 hours of sleep daily.[41,42] This research also highlighted the high prevalence of physical inactivity; which has been defined as one of the major contributors to ill-health.[43] Indeed, only 13% of the present sample were considered physically active, which is similar to lorry drivers from other countries.[1,5,12]

Using Isotemporal Substitution Modelling, our findings indicate that interchanging 30 minutes/day of sedentary time with moderate-to-vigorous stepping had positive associations with some cardio-metabolic risk markers. The protective effects of MVPA on health have previously been established;[16] these results suggest that only substituting time spent sedentary for MVPA, and not standing time or light activity, will have beneficial effects on health parameters within this population. Further research should confirm these findings.

Cardio-metabolic health profile in lorry drivers compared to other occupational drivers and the general population.

Cardiovascular diseases are the largest cause of mortality in the UK accounting for 27% of all deaths.[44] Occupational demands and unhealthy lifestyle behaviours give lorry drivers a unique constellation of risk factors for CVD. Drivers from this study showed a higher prevalence of overweight and obesity compared to males aged 45-54 years in the UK (84% versus 79.4%).[45] Weight-related co-morbidities such as type II diabetes, pre-diabetes, hypertension and metabolic syndrome were also higher in this sample compared to the general population[45,46,47] or other occupational groups[48]. The increased rates of overweight and obesity within this occupational group is a concern, given evidence suggests that obese lorry drivers are 55% more likely to have an accident than normal weight drivers[49]. In addition to this, 46% of the present sample were clustered as borderline or abnormal cases of anxiety and depression, which is higher than that seen in American lorry drivers (41.5%).[50] Job-related constraints associated with lorry driving enhance continuous psycho-physiological arousal at work, which has been linked to increased risk of ischaemic heart disease.[51,52,53]

Overall, the present findings are in-line with research conducted on US lorry drivers,[54] which demonstrate a high prevalence of unhealthy lifestyle behaviours and increased risk factors for CVD. Lorry drivers' health cannot only be explained by personal choices, but rather by a combination of lifestyle behaviours and environmental factors that encourage unhealthy diets and lack of exercise. Furthermore, lower levels of education, commonly observed within this profession, have also been linked with poor health.[55] In the present sample, 71% were educated only up to GCSE level. Lorry drivers are generally continuously exposed to unhealthy dietary adverts and messages, have less access to healthy options and have a lack of knowledge of the health impact of unhealthy lifestyle choices.[56,57] The combination of these factors (the environment, lifestyle choices and education) likely contribute towards lorry drivers' burden of disease. Indeed, US and UK data show that lorry drivers have a reduced life expectancy compared to other professions.[58,59] Despite the above evidence, lorry drivers are considered an underserved group in terms of health promotion efforts.[59]

Limitations and strengths

Limitations of the present study include the cross-sectional design which prevents us from making conclusions about causative links between sitting time and cardio-metabolic health. Secondly, the sample was recruited from one transport depot in the East Midlands, which makes it difficult to generalise findings across the UK or abroad. Thirdly, the manual approach applied to the data analysis prevents us from further exploring sedentary time patterns and bouts, which have been shown to carry prognostic relevance[60]. Finally, data collection took place during summer time, which is the busiest time at this transport company. Exploring drivers' sedentary and physical activity behaviours' across all seasons is therefore recommended for future research. Despite these limitations, this is the first study to provide objective information on lorry drivers' sitting time during workdays and non-workdays. We utilised a novel sedentary and physical activity monitor which directly distinguishes between sedentary and upright postures thus overcoming limitations of self-report measures or other types of accelerometer that do not directly measure posture. In addition we explored lorry drivers' health from a holistic perspective for a better understanding of drivers' sitting time and cardio-metabolic health.

CONCLUSION

Results from this study provide new information on lorry drivers' lifestyle behaviours and health. The high prevalence of various risk factors put drivers at high risk of numerous health conditions and premature mortality. Occupational interventions are urgently needed to reduce excessive adverse health behaviours and fatalities within this high risk workforce. Interventions should focus on reducing sitting and increasing MVPA during work breaks and leisure time. Within the present sample, and across the transport sector more broadly, our experience has shown that lorry drivers are an occupational group who have proven difficult to engage within health and wellbeing initiatives. Additional qualitative research is therefore a priority to identify effective strategies that are able to engage lorry drivers which will underpin the successfulness of future health promotion interventions.

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Disclaimer

The authors wish to state that all drivers participating in this study were medically fit to drive and comply with the DVLA requirements.

Contributors VVM and SC conceived the study. MN and JK established the partnership between the university and the local company. VVM, OO and JK designed and implemented the data collection. SC, TY, SB and DS overviewed the data collection. All authors contributed to writing and the interpretation of the results.

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Cross-sectional surveillance study to phenotype lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health

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Cross-sectional surveillance study to phenotype lorry drivers' sedentary behaviours, physical activity and cardio-metabolic health

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ABSTRACT:

Objectives: Elevated risk factors for a number of chronic diseases have been identified in lorry drivers. Unhealthy lifestyle behaviours such as a lack of physical activity (PA) and high levels of sedentary behaviour (sitting) likely contribute to this elevated risk. This study behaviourally phenotyped UK lorry drivers' sedentary and non-sedentary behaviours during workdays and non-workdays and examined markers of drivers cardio-metabolic health.

Setting: a transport company from the East Midlands, UK.

Participants: a sample of 159 male heavy goods vehicle drivers (91% White European; [median(Range)] age: 50(24, 67)years) completed the health assessments. 87 (age: 50.0(25.0, 65.0); BMI: 27.7(19.6, 43.4)kg/m^2) provided objective information on sedentary and non-sedentary time.

Outcomes: Participants self-reported their socio-demographic information. Primary outcomes: Sedentary behaviour and PA, assessed over 7 days using an activPAL3 inclinometer. Cardio-metabolic markers included: blood pressure (BP), heart rate (HR), waist circumference (WC), hip circumference (HC), body composition, and fasted capillary blood glucose (FBG), triglycerides (TGs), HDL-Cholesterol (HDL-C), LDL-Cholesterol (LDL-C) and Total-Cholesterol (TC) levels. These cardio-metabolic markers were treated as secondary outcomes.

Results: Lorry drivers' presented an unhealthy cardio-metabolic health profile (median (IQR-ranges) Systolic BP: 129(108.5, 164) mmHg; Diastolic BP: 81(63, 104)mmHg; BMI: 29(20, 47)kg/m^2; WC: 102(77.5, 146.5)cm; LDL-C: 3(1, 6)mmol/l; TC: 4.9(3, 7.5)mmol/l). 84% were overweight or obese, 43% had type 2 diabetes or pre-diabetes and 34% had the Metabolic Syndrome. The sub-sample of lorry drivers with objective postural data (n=87) accumulated 13hours/day and 8hours/day of sedentary behaviour on workdays and non-workdays ($p<0.001$), respectively. On average, drivers accrued 12min/day on workdays and 6min/day on non-workdays of moderate-to-vigorous PA (MVPA).

Conclusion: Lorry drivers demonstrate a high-risk cardio-metabolic profile and are highly sedentary and physically inactive. Interventions to reduce sitting and increase MVPA during breaks and leisure-time to improve cardio-metabolic health are urgently needed. Educational programs to raise awareness about diet and exercise are recommended.

Key words: sedentary behaviours, physical activity, cardio-metabolic health, lorry drivers, occupational health

Strengths and limitations of this study

- This study is the first to explore sedentary behaviour, physical activity and cardiovascular health amongst lorry drivers.
- The use of the latest objective monitor to measure sedentary and upright postures during workdays and non-workdays
- The cross-sectional design that prevents us from making conclusions about causative links between sitting time and cardio-metabolic health.

INTRODUCTION

Lorry driving has been considered as one of the most hazardous occupations worldwide. [1-3] Long working hours, irregular working patterns and pressures to meet delivery schedules are typical in this occupation which contribute to psychological stress and sleep deprivation.[4] Furthermore, unhealthy lifestyle behaviours such as, poor diet, lack of physical activity, smoking, high volumes of alcohol consumption, and irregular sleeping patterns are highly prevalent among this occupational group.[5-7] These features contribute to an increased risk of overweight and obesity, diabetes, hypertension, heart disease, cancer, fatigue, stress, sleep disturbance, musculoskeletal disorders,[2,6,8,9] and reduced life expectancy in lorry drivers in comparison to other occupational groups. [10-12]

Sedentary behaviours defined as “any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture”[13] are prevalent in most working-aged adults, particularly in those with driving occupations.[14] It has been established that these act as an independent risk factor for increased risk of cardiovascular disease (CVD), cardiovascular mortality (CVM), all-cause mortality, diabetes[15,16] and some cancers.[16] Links between poor cardio-metabolic health and occupational driving date back to the 1950s when Morris and Crawford (1958)[17] observed higher rates of cardiovascular events and obesity in sedentary bus drivers in comparison to active conductors.

Lorry driver’s lifestyle, in combination with their working environment embodies a constellation of risk factors for CVD. Whilst high volumes of sedentary time are assumed within this population, no study has specifically measured sedentary behaviour on workdays and non-workdays in lorry drivers. Furthermore, our knowledge related to lorry drivers' cardio-metabolic health has been derived from studies undertaken in other countries, no information currently exists on lifestyle behaviours (including sitting time and physical activity) and their relation to health in UK lorry drivers. It is essential to understand the habitual lifestyle behaviours of lorry drivers if we are to develop effective and tailored interventions to reduce the risk of the chronic diseases seen within this high-risk group. The primary aim of this study therefore was to behaviourally phenotype UK lorry drivers in terms of time spent in sedentary and non-sedentary behaviours during workdays and non-workdays and working hours and non-working hours. A secondary aim was to examine markers of cardio-metabolic health and to profile drivers' mental health.

METHODS

Study design and participants

This cross-sectional surveillance study was undertaken at a large UK-based transport company from the East Midlands. The present study is part of a programme of research undertaken in partnership with the company. This partnership was instigated by the company themselves who were seeking to better engage their drivers within the company's comprehensive health and wellbeing program. Data collection took place between May and August 2014. A volunteer sample of 159 long-distance heavy goods vehicle drivers was recruited, representing 58% of the driving workforce. Drivers were recruited across all shift patterns: morning (6:00 to 14:00), afternoon (14:00 to

22:00) and night (22:00 to 6:00) on any day of the week. Participants without current CVD, haemophilia, and any blood-borne viruses were included in the analysis. Ethical approval was obtained from the local Ethical Advisory Committee and all participants provided written informed consent.

Measurements

Participant's self-reported their age, ethnicity and average weekly working hours. Drivers were asked to complete a Health Screen Questionnaire, in which they recorded any medical problems, medication, average daily intake of fruit and vegetables, average weekly alcohol intake and smoking status (current smoker, ex-smoker, amount per week). Anxiety and depression were assessed using the Hospital Anxiety and Depression Scale (HADS).[18] Scores between 8-10 were considered borderline and those scoring 11 or over were considered as clinical 'caseness' for anxiety or depression.[18]

Resting blood pressure and heart rate were measured using the validated Omron Intellisense M7 Upper Arm monitor (Omron, UK Ltd),[19] following recommendations of the European Hypertension Society.[20] Blood pressure was classified as normal (systolic blood pressure (SBP) <120mmHg and diastolic blood pressure (DBP) <80 mmHg) pre-hypertension (SBP: 120-139mmHg OR DBP: 80-89 mmHg) and hypertension (SBP >140mmHg OR DBP >90 mmHg)[21]. Height was measured without shoes using a portable stadiometer (Seca 206, Oxford, UK). Waist circumference was assessed using anthropometric tape at the midpoint between the upper edge of the iliac crest and the inferior border of the last palpable rib. Hip circumference was measured around the widest part of the buttocks, with the tape parallel to the floor. The waist-hip ratio was subsequently calculated. Body composition and weight were assessed using a Tanita BC-418 MA Segmental Body Composition Analyzer (Tanita UK Ltd). Percent body fat measured using the Tanita BC-418 has been shown to correlate highly with the reference measure of dual-energy X-ray absorptiometry (DXA).[22] BMI was calculated as kg/m^2.

A fasted (≥ 8 h) capillary (finger-tip) blood sample was taken for the analysis of fasting blood glucose (FBG), triglycerides (TGs), High-density lipoprotein Cholesterol (HDL), Low-density lipoprotein Cholesterol (LDL) and Total-Cholesterol (TC) after heating the hand for 5 minutes. A drop of blood was taken directly from the heated finger to be analysed for FBG and TGs using the Accutrend® Plus Complete System (Roche Diagnostics, Mannheim, Germany) and HDL-C and TC using the Cardiochek PA Blood Analyser (Medisave, Dorset, UK). Both devices have been validated previously.[23,24] LDL-cholesterol was estimated from quantitative measurements of total and HDL-cholesterol and plasma triglycerides using the empirical relationship of Friedewald et al (1972).[25]

Fasting capillary blood glucose samples were converted to fasting plasma glucose using the Diabetes UK calculator[26] and further classified as normal (<6.1mmol/L), pre-diabetes (6.1 to 6.9mmol/L) and diabetes (≥7.0mmol/L).[26] Metabolic syndrome was defined according to the International Diabetes Federation as central obesity (waist circumference ≥102cm) plus any two of the following risk factors: raised blood pressure (systolic ≥130 or diastolic ≥85mmHg), raised TGs (≥1.7mmol/l), reduced HDL-C (<1.0mmol/l in males and 1.3mmol/l in females) and raised fasting plasma glucose (≥5.6mmol/l).[27] Ten year CVD risk was calculated using the QRISK calculator (http://www.qrisk.org/).[28]

Sitting, standing and physical activity

Sitting, standing and stepping time were measured objectively using an activPAL3 accelerometer, shown to be a valid measure of time spent sitting/lying, standing and walking in adults.[29,30] The activPAL3 is a small device, worn on the front of the right thigh, containing a tri-axial accelerometer which responds to signals related to gravitational forces related to thigh inclination.[31] The activPAL3 was waterproofed using a nitrile sleeve and attached to the leg using a waterproof hypoallergenic medical dressing (BSN Hypafix). This enabled participants to wear it continuously for 24 hours/day over seven days, following their health assessments. Participants were asked to complete a daily-log book where they recorded the time they went to bed and woke up on workdays and non-workdays. Information about any non-wear time was also recorded.

Data processing

Data from the activPAL were downloaded using activPAL Professional v.7.2.29 software (device firmware version 3.107) and processed manually using a customized

Microsoft Excel macro. Information on sitting, standing and stepping time, including average number of transitions from sitting to standing per waking hour, number of steps and average cadence was extracted. To be included in the analyses, participants were required to have provided at least four full days (>600 minutes of wear and >500 steps/day) of data (including at least 3 workdays and 1 non-workday). Sleeping time was identified as the last transition from standing to sitting/lying and the first transition from sitting/lying to standing during the time that best matched the participants' daily log. For each identified sleeping bout, data were explored 60 minutes before and after and included as sleeping time if sitting/lying time was ≥30 minutes and <20 steps were recorded. If any standing time with <20 steps was found during sleeping hours, this was considered as sleeping time. To control for errors associated with self-reported diary data, non-wear time was considered as time spent in either a sitting/lying or standing position for ≥3 hours, with no transitions. This cut-point was established based on checks conducted in the dataset and techniques described elsewhere.[32]

For each participant, the number of minutes spent sitting, standing and stepping and average number of transitions from sitting to standing during waking hours on workdays and non-workdays were extracted based on times derived from participants' logs. Stepping time was further classified into MVPA (by summing the minutes in which participants accumulated >100steps/minute)[33,34] and light activity (LPA, stepping time minus MVPA). Those accumulating ≤30 minutes/day of MVPA were considered physically inactive.[35]

Data analysis

Statistical analyses were conducted using SPSS v.22 (SPSS Inc., Chicago, IL, USA). All variables were checked for normality using the Shapiro-Wilk Test, which confirmed that all data were not normally distributed. Thus, non-parametric statistical tests were used throughout. Median and inter-quartile range (IQR) values were computed as descriptives for all variables. Wilcoxon-signed rank tests were used to compare the absolute time spent sitting, standing, and time in LPA and MVPA, total steps and average number of transitions from sitting to standing between workdays and non-workdays and working hours and non-working hours. Differences in outcomes between the three shift patterns (morning-06:00am-14:00-; afternoon -14:00 – 22:00-; and night -22:00 – 06:00) were explored using Kruskal-Wallis tests. Upon the result of a significant Kruskal-Wallis test, Bonferroni-corrected post hoc tests were conducted using a series of Mann-Whitney U tests to ascertain where the significant differences lay.

Data were further explored using linear regression models adopting an isotemporal substitution approach to quantify the association of substituting sitting behaviour with sleeping time, LPA or MVPA on cardio-metabolic markers. Prior to running the models, all behaviours (sleep, sitting, standing, LPA and MVPA) were divided by a constant of 30, which was considered as a unit of time equivalent to 30 minutes (this was chosen to comply with physical activity guidelines).[35] Consequently, every unit increase represents 30 minutes/day of any of the behavioural variables. This is a novel approach that takes into account a finite amount of time and has been recommended when assessing physical activity and sitting behaviours.[36-38]

The isotemporal substitution models were fitted to explore the impact of interchanging units of time spent sitting by any intensity of physical activity or sleeping on cardio-metabolic markers. Consequently, average wear time, sleeping time, time in LPA and MVPA were entered concurrently into a linear regression model. This was further adjusted to control for potential cofounding variables such as age, ethnicity, education levels, shift pattern, smoking, alcohol intake and fruit and vegetable consumption. Results were also adjusted by BMI. The linear coefficient for sleeping, LPA and MVPA represent the association of substituting a given unit of sitting time into each category, respectively.[36]

RESULTS

Participants

A sample of 159 male lorry drivers participated in the health assessments (median (IQR-ranges): age: 50.0 (24.0, 67.0) years; BMI: 29(20, 47) kg/m^2). Out of the main cohort (N=159) a sub-sample of 87 lorry drivers (55%) provided additional valid activPAL data (age: 50.0(25.0, 65.0) years; BMI: 27.7(19.6, 43.4) kg/m^2). Those not complying with the activPAL protocol for valid data (n=72; age: 52.0(24.0, 67.0) years) had significantly higher waist-hip ratio (0.96 (0.81, 1.15)), percentage body fat (27.1(15.4, 44.5) %), BMI (29.9(19.9, 47.2) kg/m^2), FBG (5.7 (4.0, 9.1) mmol/l) and lower alcohol consumption (units of alcohol: 7.9 (1.0, 23.0)) in comparison to those providing valid activPAL data.

Cardio-metabolic health profile

Table 1 displays participants' socio-demographic information, medical information and cardio-metabolic markers measured for the whole sample (N=159) and for the sub-sample (n=87). Significant differences between the main cohort and the sub-cohort were only found for education levels. Although lorry drivers participating in this study were classed as medically fit to drive, the sample displayed a high-risk cardio-metabolic profile (Table 1). Out of 159 drivers, 84% were overweight or obese, 10% had diagnosed type II diabetes, 29% had pre-diabetes, 4% had undiagnosed diabetes, 34% had the Metabolic Syndrome, 27% were pre-hypertensive, 29% were hypertensive, 24% possessed >10% risk of having a cardiovascular event in the next ten years and 15% were current smokers. In addition, of those who provided activPAL data (n=87), 87% were classified as physically inactive.

Table 1. Participants' demographic information. Median and IQR values are shown for the body measurements, blood pressure, blood markers and lifestyle factors for the whole sample of UK lorry drivers (N=159) and the sub-sample (n=87) who provided activity data.

	Total sample (Median (range)/number (%))	Sub-sample (Median (range)/number (%))	Differences (p value)
Age (yrs.)	50.0 (24.0, 67.0)	50(25.0, 65.0)	.504
Avg. working hours (h/week)	48.0 (27.0, 70.0)	48(27.0, 60.0)	.198
Ethnicity			.259
White European	91.0%	95.5%	
Asian/Asian British	4.5%	1.1%	

Black Caribbean	2.5%	2.3%	
Other	2.0%	1.1%	
Highest level of Education			.019
GCSEs	71.0%	94.0%	
A-levels	9.0%	2.3%	
Other	11.0%	4.5%	
Medical Information			.833
CV-related medication (BP, Thrombosis, Cholesterol)	12.4%	11.4%	
Anxiety (borderline/abnormal)	31.0%	35.2%	.314
Depression(borderline/abnormal)	15.5%	17.0%	.872
Body Composition			
% Body fat	26.0(12.2, 44.5)	24.8(12.2, 43.3)	.200
Waist circumference (cm)	102.1(77.5, 146.5)	100.9(77.5, 141.0)	.412
Waist-Hip ratio (cm)	0.95(0.8, 1.1)	0.93(0.8, 1.1)	.100
BMI (kg/m^2)	28.8(19.6, 47.2)	27.7(19.6, 43.4)	.176
Blood Pressure			
Systolic blood pressure (mmHg)	129.0(108.5, 164.0)	129.0(108.5, 155.0)	.574
Diastolic blood pressure (mmHg)	81.0(63.0, 104.0)	81.0(65.0, 104.0)	.362
Heart rate (beats/min)	62.0(42.0, 89.0)	61.0(42.0, 89.0)	.292
Blood Markers (mmol/l)			
FBG	5.4(3.7, 12.7)	5.1(3.7, 12.7)	.491
HDL-C	1.4(0.6, 2.6)	1.4(0.9, 1.7)	.578
LDL-C	3.0(1.0, 5.7)	3.2(1.0, 5.4)	.151
TG's	1.5(0.1, 6.9)	1.5(0.7, 4.3)	.142
TC	4.9(2.6, 7.5)	5.1(2.6, 7.3)	.107
Lifestyle behaviours			
Avg. fruit and vegetables /day	5.0(0.0, 15.0)	4.3(0.0, 11.5)	.465
Alcohol units/week (n=111; sub-sample n= 88)	9.0(1.5, 60.0)	10.0(5.0, 60.0)	.129
Cigarettes/week (n=89; sub-sample n=55)	122.5(2.0, 700.0)	140.0(20.0, 700.0)	.291

activPAL-determined sitting, standing, light physical activity and MVPA.

Participants providing valid activPAL data wore the device continuously (24 hours per day) for at least four days, overall this sample had a median wear duration of 6.5 (0.7) days. Median activPAL-determined waking hours were greater for workdays than for non-workdays (p<0.001). Participants' accumulated significantly greater amounts of sitting time on workdays compared to non-workdays and during working hours compared to non-working hours (Table 2). Consequently, drivers accrued more standing time and time in LPA on non-workdays and during non-working hours. Nevertheless, participants acquired double the amount of time in MVPA (p<.001) on workdays than non-workdays and broke up their sitting time more often non-working hours compared to working hours (p=.031) (table 2).

Table 2. Sleeping, sitting, standing, light and MVPA and transitions from sitting to standing during workdays and non-workdays and working hours to non-working hours in a sample of lorry drivers from the East Midlands, UK. (n=87)

	All days (median ± IQR)			Work days only (median ± IQR)		
	Workdays	Non-workdays	Differences (p value)	Working hours	Non-working hours	Differences (p value)
Sleep time (mins/day)	399.8(158.0, 774.3)	576.8(258.6, 886.9)	**< 0.001**			
Waking time (mins/day)	1040.1(813.4, 1395.4)	861.2(465.6, 1181.3)	**< 0.001**	628.8(344.7, 838.1)	421.4(136.1, 770.1)	**< 0.01**
Time spent sitting (mins/day)	749.5(493.5, 1179.9)	463.1(258.0, 787.9)	**< 0.001**	491.5(148.6, 678.2)	239.9(101.8, 600.4)	**<0.001**
Time spent standing (mins/day)	188.7(83.3, 414.2)	226.8(85.7, 501.9)	**< 0.001**	70.4(24.6, 284.1)	105.5(27.6, 302.5)	**< 0.001**
Time in light PA (mins/day)	85.3(48.0, 169.2)	97.6(27.2, 317.2)	**<0.01**	39.7(8.2, 95.8)	47.0(9.6, 118.6)	**< 0.05**
Time in MVPA (mins/day)	12.6(1.4, 103.5)	6.0(0.0, 84.4)	**< 0.001**	4.4(0.3, 26.2)	5.8(0.0, 96.0)	**< 0.01**
Total steps per day	8074.9(3411.3, 21420.0)	7854.8(1008.0, 23308.0)	.656	3659.9(2148.4, 9177.9)	4324.5(634.0, 17469.0)	.052
Number of transitions from sitting to standing per waking hour	2.8(1.4, 7.9)	2.9(1.2, 8.4)	.231	2.7(1.0, 8.4)	3.1(0.5, 9.0)	**<0.031**

Table 3 displays socio-demographic information, BMI, and activity data on workdays' for each shift pattern. Morning shift workers had greater sleeping times and lower sedentary times on workdays compared to the other shift groups. Afternoon shift workers accumulated less transitions from sitting to standing compared to morning and night workers during non-workdays (afternoon shift: 31.5(21.0, 63.0); morning shift: 47.5(16.0, 100.0); night shift (46.0(21.0, 91.0); $p<.05$) and during non-working hours compared to night workers (afternoon shift: 16.9(8.0, 51.0); night shift (25.2(14.0, 37.0); $p<.01$) No other significant differences were observed between shift groups on workdays (Table 3) or non-workdays (data not shown).

Table 3. Median and range values for age, average working hours, BMI, and activity data on workdays by shift pattern in a sample of lorry drivers from the East Midlands, UK. (n=87)

	Morning shift Median(range) n = 42	Afternoon shift Median(range) n = 21	Night shift Median(range) n = 24	Differences (p value)
Age (yrs.)	51.0 (27.0, 65.0)	48.0 (28.0, 58.0)	49.5 (25.0-60.0)	.471
Avg. working hours (h/day)	10.15(5.46, 12.5)	10.5(9.2, 14.24)	10.2(9.3, 14.33)	**<0.05**
BMI (kg/m^2)	27.8(22.0, 38.7)	30.2(27.7, 43.4)	27.4 (19.6-38.6)	.507
Sleep time (mins/day)	461.3(342.3, 626.6)	316.1(157.9, 774.3)	329.9(232.2-462.3)	**<0.001**
Waking hours (mins/day)	995.0(813.4, 1116.7)	1063.2(942.2, 1395.4)	1095.7(977.7, 1207.8)	**<0.001**
Time spent sitting (mins/day)	682.5(493.5, 853.9)	779.9(556.1, 1179.9)	785.9(680.3-884.1)	**<0.001**
Time spent standing (mins/day)	177.6(91.62, 339.6)	174.6(90.0, 414.2)	194.0(133.3, 269.3)	.243
Time in light PA (mins/day)	82.1(48.0, 169.2)	81.9 (48.7, 149.4)	94.8(66.7, 140.5)	.166
Time in MVPA (mins/day)	12.6 (1.4, 103.5)	10.0(2.0, 53.7)	15.2(3.5, 72.0)	.961
Total steps per day	7551.6(4136.7, 12516.4)	8083.2(4824.7, 11895.0)	9010.0(5999.2, 15618.5)	.141
Transitions from sitting to standing per waking hours	2.8(0.8, 0.9)	2.6(1.8, 7.8)	2.9 (2.0, 4.7)	.774

* All significant P values indicate a significant difference between the morning shift group and the other two groups.

Tables 4 and 5 show the results of the Isotemporal Substitution Models which examined the impact of interchanging units of time spent sitting with LPA, MVPA or sleep on cardio-metabolic markers on workdays and non-workdays. Substituting 30 minutes of sitting for MVPA was associated with a significant reduction in waist circumference, triglycerides and HDL-cholesterol on workdays (Table 4). These results remained significant after adjusting for BMI. No significant associations were observed in relation to substituting sitting time for light activity or sleep on workdays. No significant associations were observed when substituting 30 minutes of sitting for light activity or MVPA on non-workdays. Yet, a negative association was found between substituting 30 minutes of sitting with sleep on BMI on non-workdays (Table 5).

Table 4. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, Pulse, Glucose, Triglycerides, HDL, LDL and Total cholesterol using isotemporal substitution on workdays in a sample of lorry drivers from East Midlands, UK.

	Sedentary to standing	P value	Sedentary to Light stepping Workdays	p value	Sedentary to moderate or vigorous stepping on Workdays	p value	Sedentary to Sleep on Workdays	p value
Waist Circumference	-0.1(-1.4, 1.2)	.870	-0.6(-3.9, 2.7)	.707	-6.5(-11.0, -1.9)	**<0.01**	0.1(-0.3, 0.5)	.500
BMI	0.07(-0.4, 0.6)	.775	-0.7(-1.9, 0.5)	.247	-1.5(-3.2, 0.2)	.089	-0.0(-0.2, 0.1)	.970
Systolic BP	0.6(-0.6, 1.9)	.338	-1.9(-5.1, 1.3)	.232	-1.1 (-5.5, 3.3)	.616	-0.3(-0.4, 0.4)	.885
Diastolic BP	0.6(-0.5, 1.7)	.313	-1.8(-4.7, 0.9)	.201	0.1(-3.8, 4.0)	.952	-0.2(-0.5, 0.2)	.280
Fasting Glucose	-0.01(-0.1, 0.1)	.859	-0.04(-0.3, 0.2)	.774	-0.3(-0.6, 0.1)	.144	-0.04(-0.1, 0.02)	.137
Triglycerides	0.00(-0.1,0.1)	.940	0.06(-0.2, 0.3)	.687	-0.4(-0.8, 0.01)	**.051**	0.02(-0.01, 0.05)	.286
HDL Cholesterol	-0.02(-0.06,0.01)	.247	-0.1(-0.2,-0.01)	.035	0.3(0.1, 0.4)	**<0.01**	-0.01(-0.02, 0.01)	.314
LDL Cholesterol	-0.04(-0.2,0.1)	.559	0.2(-0.1, 0.6)	.209	-0.1(-0.6, 0.5)	.748	-0.02(-0.07, 0.02)	.281
Total Cholesterol	-0.6(-0.07,0.02)	.259	0.1(-0.2, 0.5)	.509	0.05(-0.4, 0.6)	.832	-0.2(-0.07, 0.02)	.259

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour

Table 5. Association of substituting 30min of sedentary behaviour for LPA, MVPA or sleep time with measures of WC, BMI, Blood Pressure, Pulse, Glucose, Triglycerides, HDL, LDL and Total cholesterol using isotemporal substitution on non-workdays in a sample of lorry drivers from East Midlands, UK.

	Sedentary to standing	P value	Sedentary to Light stepping on Non-Workdays	p value	Sedentary to moderate or vigorous stepping on non-Workdays	p value	Sedentary to Sleep on Non-Workdays	p value
Waist Circumference	-0.4(-1.2, 2.1)	.428	0.4(-1.3, 2.1)	.612	-0.8(-4.8, 3.2)	.695	-0.4 (-1.1, 0.5)	.215
BMI	0.1(-0.5, 0.2)	.369	-0.2(-0.8, 0.4)	.509	0.2(-1.2, 1.7)	.746	-0.3(-0.5, -0.05)	**.019**
Systolic BP	-0.3(-1.1, 0.5)	.497	0.3(-1.3, 1.9)	.683	-0.01 (-3.7,3.7)	.994	-0.6(-1.2, 0.1)	.076
Diastolic BP	-0.5(-1.2, 0.2)	.167	-0.5(-1.9, 0.9)	.462	0.3(-2.9, 3.6)	.839	-0.3(-0.9, 0.2)	216
Fasting Glucose	0.01(-0.07, 0.1)	.753	0.03(-0.1, 0.2)	.648	-0.3(-0.7, 0.05)	.090	-0.00(-0.06, 0.06)	.931
Triglycerides	-0.03(-0.1,0.04)	.417	0.07(-0.07, 0.2)	.303	-0.2(-0.5, 1.0)	.380	-0.02(-0.08, 0.04)	.500
HDL Cholesterol	0.02(-0.01,0.05)	.281	-0.05(-0.1, 0.01)	.119	0.07(-1.0, 0.2)	.359	0.0 (-0.02, 0.03)	.732
LDL Cholesterol	-0.08(-0.2,0.01)	.084	0.0(-0.2, 0.2)	.919	-0.01(-0.5, 0.4)	.946	-0.04(-0.2, 0.04)	.084
Total Cholesterol	-0.08(-0.2,0.02)	.100	-0.03(-0.2, 0.1)	.887	0.03(-0.4, 0.5)	.887	-0.03(-0.1, 0.04)	.368

Abbreviations: LPA, light physical activity, MVPA, moderate-to-vigorous physical activity. Coefficients represent the factor by which the cardio-vascular markers are multiplied by (95% confidence interval) for a 30min difference in the substituted physical activity behaviour

DISCUSSION

This cross-sectional study highlights the high-risk cardio-metabolic health profile and the high levels of objectively measured sitting time and low levels of MVPA amongst a sample of UK lorry drivers. This study is the first of its kind to objectively measure lorry driver's sedentary behaviours using inclinometry, which were particularly high on workdays (13 hours/day) compared to non-workdays (8 hours/day). Using an isotemporal modelling approach, this study indicates that reallocating 30 minutes of sedentary time to moderate-to-vigorous stepping, during workdays, and sleeping time, on non-workdays, was linked to favourable levels of triglycerides, HDL-cholesterol, BMI and waist circumference.

Sitting, standing and movement patterns in lorry drivers compared to other occupational drivers and the general population.

Occupational drivers can be defined as "compulsory sedentary workers", yet limited research has directly examined sedentary time in this occupational group and of the research available,[14,17,39,40] only one study used similar methods.[14] Prolonged time sitting has been strongly related to higher rates of overweight and obesity, adverse cardiovascular biomarkers, premature mortality, the Metabolic Syndrome and depression.[15,41,42] The present findings suggest that lorry drivers accumulate the highest sitting time volumes on workdays reported up to date (13hours/day). These are slightly higher than those seen in bus drivers (12hours/day), who have been found to be highly sedentary, compared to the general population.[14] This sample of drivers spent less time sedentary on non-workdays compared to workdays (8 hours/day versus 13 hours/day), which could in part be explained by the observation that drivers accumulated more sleeping time during non-workdays (576.8 (258.6, 886.9) minutes) than workdays (399.8 (158.0, 774.3)minutes). This could be understood as a compensational behaviour for the shortage of sleep during workdays induced by the shift patterns and long hours at work. Indeed, several studies have shown that lorry drivers are a sleep deprived group due to their shift patterns and work duration, averaging 3.8 to 5.2 hours of sleep daily.[43,44] This research also highlighted the high prevalence of physical inactivity; which has been defined as one of the major contributors to ill-health.[45] Indeed, only 13% of the present sample were considered physically active, which is similar to lorry drivers from other countries.[1,5,12]

Using Isotemporal Substitution Modelling, our findings indicate that interchanging 30 minutes/day of sedentary time with moderate-to-vigorous stepping had positive associations with some cardio-metabolic risk markers. The protective effects of MVPA on health have previously been established;[16] these results suggest that only substituting time spent sedentary for MVPA, and not standing time or light activity, will have beneficial effects on health parameters within this population. Further research should confirm these findings.

Cardio-metabolic health profile in lorry drivers compared to other occupational drivers and the general population.

Cardiovascular diseases are the largest cause of mortality in the UK accounting for 27% of all deaths.[46] Occupational demands and unhealthy lifestyle behaviours give lorry drivers a unique constellation of risk factors for CVD. Drivers from this study showed a higher prevalence of overweight and obesity compared to males aged 45-54 years in the UK (84% versus 79.4%).[47] Weight-related co-morbidities such as type II diabetes, pre-diabetes, hypertension and metabolic syndrome were also higher in this sample compared to the general population[46,47,48] or other occupational groups[49]. The increased rates of overweight and obesity within this occupational group is a concern, given evidence suggests that obese lorry drivers are 55% more likely to have an accident than normal weight drivers[50]. In addition to this, 46% of the present sample were clustered as borderline or abnormal cases of anxiety and depression, which is higher than that seen in American lorry drivers (41.5%).[51] Job-related constraints associated with lorry driving enhance continuous psycho-physiological arousal at work, which has been linked to increased risk of ischaemic heart disease. [52-54]

Overall, the present findings are in-line with research conducted on US lorry drivers,[55] which demonstrate a high prevalence of unhealthy lifestyle behaviours and increased risk factors for CVD. Lorry drivers' health cannot only be explained by personal choices, but rather by a combination of lifestyle behaviours and environmental factors that encourage unhealthy diets and lack of exercise. Furthermore, lower levels of education, commonly observed within this profession, have also been linked with poor health.[56] In the present sample, 71% were educated only up to GCSE level. Lorry drivers are generally continuously exposed to unhealthy dietary adverts and messages, have less access to healthy options and have a lack of knowledge of the health impact of unhealthy lifestyle choices.[57,58] The combination of these factors (the environment, lifestyle choices and education) likely contribute towards lorry drivers' burden of disease. Indeed, US and UK data show that lorry drivers have a reduced life expectancy compared to other professions.[59,60] Despite the above evidence, lorry drivers are considered an underserved group in terms of health promotion efforts.[61]

Limitations and strengths

Limitations of the present study include the cross-sectional design which prevents us from making conclusions about causative links between sitting time and cardio-metabolic health. Secondly, the sample was recruited from one transport depot in the East Midlands, which makes it difficult to generalise findings across the UK or abroad. Thirdly, the manual approach applied to the data analysis prevents us from further exploring sedentary time patterns and bouts, which have been shown to carry prognostic relevance[62]. Finally, data collection took place during summer time, which is the busiest time at this transport company. Exploring drivers' sedentary and physical activity behaviours' across all seasons is therefore recommended for future research. Despite these limitations, this is the first study to provide objective information on lorry drivers' sitting time during workdays and non-workdays. We utilised a novel sedentary and physical activity monitor which directly distinguishes between sedentary and upright postures thus overcoming limitations of self-report measures or other types of accelerometer that do not directly measure posture. In addition we explored lorry drivers' health from a holistic perspective for a better understanding of drivers' sitting time and cardio-metabolic health.

CONCLUSION

Results from this study provide new information on lorry drivers' lifestyle behaviours and health. The high prevalence of various risk factors put drivers at high risk of numerous health conditions and premature mortality. Occupational interventions are urgently needed to reduce excessive adverse health behaviours and fatalities within this high risk workforce. Interventions should focus on reducing sitting and increasing MVPA during work breaks and leisure time. Within the present sample, and across the transport sector more broadly, our experience has shown that lorry drivers are an occupational group who have proven difficult to engage within health and wellbeing initiatives. Additional qualitative research is therefore a priority to identify effective strategies that are able to engage lorry drivers which will underpin the successfulness of future health promotion interventions.

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Disclaimer

The authors wish to state that all drivers participating in this study were medically fit to drive and comply with the DVLA requirements.

Contributors VVM and SC conceived the study. MN and JK established the partnership between the university and the local company. VVM, OO and JK designed and implemented the data collection. SC, TY, SB and DS overviewed the data collection. All authors contributed to writing and the interpretation of the results.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(✔) Indicate the study's design with a commonly used term in the title or the abstract (within title page, page 1)
		✔*b*) Provide in the abstract an informative and balanced summary of what was done and what was found (page 2 and 3)
Introduction		
Background/rationale	2	✔Explain the scientific background and rationale for the investigation being reported (page 4 and 5)
Objectives	3	✔State specific objectives, including any prespecified hypotheses (page 5)
Methods		
Study design	4	✔Present key elements of study design early in the paper (within methods section, study design and participants, page 5 and 6)
Setting	5	✔Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection (within methods section, study design and participants, page 5 and 6)
Participants	6	(✔) Give the eligibility criteria, and the sources and methods of selection of participants (within methods section, study design and participants, page 5 and 6)
Variables	7	✔Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable (within methods section, measurements, page 6 to 8)
Data sources/ measurement	8*	✔For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group (within methods section, measurements, page 6 to 8)
Bias	9	✔Describe any efforts to address potential sources of bias (within methods section, measurements, page 6 to 8)
Study size	10	✔Explain how the study size was arrived at (within methods section, study design and participants, page 5 and 6 and results section page 11 and 12)
Quantitative variables	11	✔Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why(within methods section, data processing and analysis page 9 to 11)
Statistical methods	12	(✔) Describe all statistical methods, including those used to control for confounding (within methods section, data analysis page 10 to 11)
		(✔) Describe any methods used to examine subgroups and interactions (within methods section, data analysis page 10 to 11)
		(✔) Explain how missing data were addressed (within results section, page 10 to 11)
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(✔) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (within results section, page 10 to 12)
		(✔) Give reasons for non-participation at each stage (within results section, page 10 to 12)
		() Consider use of a flow diagram (flow diagram not needed)
Descriptive data	14*	(✔) Give characteristics of study participants (eg demographic, clinical, social) and

		information on exposures and potential confounders (within results section, page 10 to 12)
		(✔) Indicate number of participants with missing data for each variable of interest (within results section, page 10 to 12)
Outcome data	15*	✔Report numbers of outcome events or summary measures (within results section, page 10 to 20)
Main results	16	(✔) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (within results section, page 19 and 20)
		(✔) Report category boundaries when continuous variables were categorized included (methods section, page 6 and 9)
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	✔Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses (methods section, data analysis page 10 and 11; results page 19 and 20)
Discussion		
Key results	18	✔Summarise key results with reference to study objectives (discussion, page 21 to 24)
Limitations	19	✔Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias (strengths and limitations of the study, page 24 to 25)
Interpretation	20	✔Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (discussion, page 21 to 24 and limitations of the study page 24 and 25)
Generalisability	21	✔Discuss the generalisability (external validity) of the study results (strengths and limitations of the study, page 24)
Other information		
Funding	22	✔Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (page 26)

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.